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LVI. ON THE NON-VISUAL PERCEPTION OF THE LENGTH OF  
VERTICALLY WHIPPED RODS

By ERNA SHULTS

This study supplements, on one side, the previous work of Hoisington.<sup>1</sup> The former study dealt with the cutaneously determined perception of the length of rods in its simplest form; this study takes up the analysis of the same perception at a more complex level. Here we inquire as to the experience had when *O* whips the rod, rather gently, in the vertical plane. Movement is usually present in our everyday experience with tools and instruments; hence we ask whether the moving stimulus more accurately conditions the perception by way of additional sensory processes or of additional sensory variables, or whether with the moving stimulus any new centrally aroused factors appear which would seem to be essential elements in the perception. The results can tell us nothing about the perception when the end of the moving stimulus-object is in contact with a surface.

The general procedure was the same as that used by Hoisington; *i. e.*, we used five variable stimuli, two above, two below and one equal to the standard stimulus; we used the two time-orders at random but in equal number; we varied the moments of length, weight and center of mass, and the *O* made comparative judgments, always judging the length of the second rod in terms of the first. We reconstructed the apparatus so that it consisted of a rigidly braced wedge-shaped basket which swung from the ceiling. Two arcs, whose radii were the distance from the bottom of the basket to the ceiling, set about 45 cm. apart in the plane of swing, made up the bottom; shallow beds on the upper side of this arc carried the rods which lay horizontally and at right angles to the plane of swing. *E*, by shifting a lever from which a cord passing over silent pulleys ran to the swinging basket, could bring any desired rod immediately in front of *O* and always at the same height; a weight acting over a pulley drew the basket in the opposite direction. This apparatus was to all intents and purposes noiseless.

The *Os* were Miss C. C. Braddock (B), scholar in psychology; S. Feldman (F), assistant in psychology; and L. B. Hoisington (H), assistant professor of psychology. B was a somewhat experienced *O*; F had had very little experience; H was well trained, having observed in the previous work. B and F were completely ignorant of the nature of the problem attacked and of changes made in the stimuli.

The instructions, which the *Os* read from a typewritten copy, were: "You will be given two rods in succession. You will take each in turn and whip it up and down twice. You are to judge the length of the second rod in terms of the first, *i. e.*, you will judge the second as longer than, equal to, or shorter than the first." After some preliminary trials the *Os* agreed that a double whip was the best; it was not long enough to give rise to much reflection or to blot out the previous experience, nor yet too short to give a clear experience. If *O* continued the whip too long, or if he felt unable to make a comparative judgment, *E* presented the pair at some later time in the series.

The serial nature of the work depended upon the different ordering of the three moments; in Series I all three moments (length, weight and center of mass) varied; in Series II length alone varied; in Series III only center of mass varied; and in Series IV only weight varied. The standard rod was 85 cm. long, the variables differed by increments and decrements of 5.5 and 11 cm.; it weighed 100 gr., the variables weighed 2 and 4 gr.

<sup>1</sup>L. B. Hoisington, On the Non-Visual Perception of the Length of Lifted Rods, *Amer. J. Psych.*, 1920, 31, 114-146.

more and less; it had its center of mass 15 cm. out from the front of the handle, the variables had theirs at 6 and 12 mm. farther and nearer. We took 50 comparative judgments for every variable in all series except the first, in which we took 100 judgments. After we had completed the psychophysical work we went through the series again in the same order, but this time *O* reported process in addition to giving his judgment. We hoped, by this complete separation of the quantitative and qualitative parts of the experiment, that *O* would not attend to process during the psychophysical series but would give himself up wholly to the perception. In the early part of the experiment, especially, attention to process makes the judgment less certain if not more variable. There is some evidence, however, that *B* sought more or less constantly throughout the whole course of the experiment for an existential basis for her judgments; it was as if there were an attempt to justify the one in terms of the other or to correlate across from judgment to process. There can be no doubt either that both *B* and *F* confused the factors of weight and length; they did not, apparently, distinguish between the greater absolute intensity of pressure due to weight and the greater relative intensity due to the rod acting as a longer lever in the hand. *B*, at least, finally overcame the confusion, but not till she came to the introspective part of the work; a fact which may cast some doubt upon the wisdom of the plan of separating the two phases of the work or upon the order in which they came.

*Quantitative Results.*—The results shown in Table 1<sup>2</sup> are in terms of  $h'$  and  $L'$  computed according to Urban. The use of these values does not commit us on the question of the limen; it simply takes these measures as indicative of the degree to which a given set of conditions determines the perception. A small  $h'$  and a large  $L'$  stand for flat or irregular distributions, while a large  $h'$  and a small  $L'$  go with steeper curves of distribution which have no inversions, at any rate of the first order. E. G. Boring, in an unpublished communication, also suggests this use of  $h'$  in cases where the unit of measurement for purposes of correlation is in doubt. We need no more than call attention to the fact that  $h'$  and not  $L'$  is the measure which marks the steepness of the curve, and that  $h$  and  $L$  will differ from their primes according to the unit-steps, since the one is the quotient and the other the product of that unit, whatever it is. Although the lack of a known unit of stimulus with which to correlate deprives us of the true  $h$  and of the  $DL$ , we may, for purposes of comparison, place our five variables at equal intervals along the abscissa, and indicate them simply by the numbers from 1 to 5, when the  $h$ 's and  $L$ 's become in so far comparable with their own kind. Such a procedure can stand only as a makeshift in the face of ignorance; the real solution lies in complete analysis or in a new mode of attack in the case of these complexly integrated perceptions.

The psychophysical results show little that is new so far as the relative effectiveness of the three moments as conditions of the perception is concerned. The one outstanding fact brought out in this connection is the greater effectiveness of center of mass with the rods whipped up and down over that found for the bare lifting of the rods. The increments, 6 mm., are about one-half those used by Hoisington.<sup>3</sup> As we shall see presently, the factors of temporal variation and of spread of pressure were important on the experimental side.

The results of *H* show clearly the importance of center of mass as the determining condition of the perception. It is plain from *H*'s results for Series I and III that differences of weight or of length condition somewhat, although perhaps only secondarily, the perception; it is just as apparent when we take the results for Series II and IV that it is length rather than

<sup>2</sup>See p. 140. <sup>3</sup>*Op. cit.*, 116, Table I, Series AI and BI.

weight which is the conditioning factor, a fact which comes out more clearly in a Study which is to follow. This conclusion does not hold for the other two *Os*, for whom, as we have said, weight played a large part. *F*, in the introspective series, almost always reported the one or the other of the rods as lighter or heavier than the other; he seemed unable to escape difference of weight even when instructed to judge length or to report process. Hence Series II yields the smallest values for *h'* and Series IV for the judgment 'longer' yields a value greater than the corresponding value for Series III, although their relative as well as their absolute magnitude reverses for the judgment 'shorter' in the same series. The results of *B* show little that is significant. The largest *h'* occurs for Series II, the largest average is for Series I and the smallest for Series IV, but the differences are not large when compared with the variability found between the results for the judgments 'longer' and 'shorter'. *B*, in all except Series IV, gives higher values for *h'* with the judgment 'shorter'; *F* gives the larger values with the judgment 'longer' in all except Series III; and *H* in all except Series I, where the difference is very slight. These results of *F* and *H* agree with those obtained by Hoisington.<sup>4</sup>

*Qualitative Results.*—A summary of the reports of *B* for Series I shows that the judgment 'longer' goes with more intense, bulky, massive pressures in the hand which show greater extent; the presence of pressure and strain sensations in the arm with the up-whip; a slower, more constant and greater increase and decrease of intensity of pressure with whipping; a relatively more intense pressure at the back of the hand than at the front and, at first, a considerable amount of visual imagery. The report of experience with the judgment 'shorter' gave, in general, just the opposite. The following reports are typical: (4-3—) "With the first, a bulky pressure at the base of the thumb and in the palm of the hand; the bulkiness greater and pressure more intense in palm. In whipping rod, the pressure seemed to fall back heavily on palm with a steady increase in intensity. Slight sensations of strain along back of hand and in wrist with the lift. With second rod, the same experience but less intense. The pressure was more evenly distributed between palm of hand and thumb. The rod jumped up more easily and gave a more definite pressure on the forefinger." (3-1—) "Lighter pressure in palm, on thumb and forefinger. A more surfacy, more cutaneous pressure with second than with the first. Kinaesthetic sensations in hand with both. Visual image with second of light yellowish, greyish thing which meant rod." (3-5+) "Second heavier, more bulk in hand, a bulkier pressure on thumb. Visual images of a short rod and of a longer and thicker one. Moving pressure in first seemed to come up more quickly; second seemed to be dragged down by something." (3-5+) "Pressure dull heavy on thumb, also pressure in palm and on forefinger. Sudden increase and slow decrease of pressure on finger. First, lighter; moving pressure gave less change in intensity."

*F* found much difficulty in reporting so complex an experience. At first, it was a matter of weight and of the angle at which the rod dropped down; later, it was a matter of comparison of fore and back pressures; the act of whipping seemed to be an inadequate stimulus for reportable experience. A few reports follow:

(3-5—) "Second heavier. Very heavy at point quite distant from handle. Could not definitely localize end point of second." (3-4+) "First heavier at end; second grew lighter toward the end." (3-5+) "Pressure more intense in second. Pressure in forefinger more intense with second than with first. Proportionately more intense in relation to pressure at base of thumb." (1-3+) "First pressure greater at base of thumb, second

<sup>4</sup>*Op. cit.*, 146.

pressure greater at side of finger." (5-3—) "Pressure on forefinger greater than that at base of thumb in both. Difference between pressures less in the second."

H reported temporal differences both in rate of change of intensity with whipping and in the rapidity with which maxima of intensity, as the rod came down, followed each other; differences in relative and absolute changes in intensity with whipping, with correlated changes in quality; differences in the extent of the pressure pattern, and differences in the relative intensity of the fore and back pressures. With the shorter rods the pressure at the base of the thumb was relatively less intense, and fluctuated more rapidly and through a relatively wider range, passing very quickly from almost zero to maximal intensity; the total pattern while a unity yet showed focal points at the base of the thumb and on the forefinger with little pressure in between (it was often of neutral quality with contact-fringes which gave the impression of liveliness); with the long rods, or those which gave rise to the meaning longer, the fluctuations with whipping were slower in alternation, the intensity increased and decreased more slowly with the maximum maintained for an appreciable time, and the pressure extended over the whole of the inner part of the hand or nearly so, with a dull, draggy, 'dead' quality. The following are sample reports.

(3-2—) "Pressure on forefinger and on base of thumb less intense with the second; the difference was greater in the case of the back pressure. Variations in intensity with whipping relatively greater in second and the shifts were more rapid." (1-3+) "More intense pressure with the second especially at back of hand. Fluctuations slower with relatively slightly less change in intensity. A little more extended pressure pattern with the quality a little duller at moments of greatest intensity."

The reports from Series III add but little to the above; there is perhaps a slight difference in degree. A couple of reports from every *O* will serve. (1-4+) "With the second the whole thing was a bigger experience. Slight strain. Sudden increase with slow decrease. With the first a sudden decrease of intensity" (B). (2-3+) "Pressure at base of thumb and in palm bulkier with second. Also a definite increase in intensity of pressure on the forefinger. It was the way it increased and decreased; as the rod came down it increased very quickly but decreased very slowly" (B). (4-3—) "Pressure greater in first; in second, pressure greater at base of thumb" (F). (3-5—) "Pressure in first greater than in second; pressure in first on forefinger greater than pressure on forefinger in second" (F). (1-4+) "Fore pressure a little more intense and a little duller with the second; back pressure considerably more intense and duller. With second the pressure pattern was more sharply defined in extent and showed greater variation in intensity and a longer interval with whipping" (H). (5-3—) "Both pressures less intense with the second, especially the back pressure. With first a dull pressure fairly sharply defined in extent; second, neutral pressure with a hint of contact. Less change in intensity with whipping than with first" (H).

Series IV yields nothing save differences of absolute intensity of pressures. These differences proved adequate to touch off the meaning of difference of length, although there is no evidence that they in any way conditioned the true perception of length.

In Series II, especially if *O* began the whip rather quickly, the longer rods responded less readily; there was a temporal lag with increase of intensity on the forefinger. This temporal difference in formation and change of pattern gave rise to a perception of difference in length; the difference tended to disappear as the rods got under way and settled to a slow uniform rate of movement. The reports are not entirely unequivocal. (3-1—) "Sensations in wrist; a sort of pushing up of the hand. Increase in intensity but it did not increase as much as I expected it would" (B). (3-2—)

"Lighter pressure with the second. Less subcutaneous and more cutaneous on the forefinger. Slow increase in intensity when the rod came down and quick decrease when the rod went up" (B). (5-3—) "Alternation of pressures quicker with the second than with the first. Less intense pressure with the second" (B). (2-3+) "A heavier pressure on the palm with the second. Slow alternation between the pressure on the finger and that on the thumb which gave the idea that the rod was hard to lift" (B). (3-2—) "First pressure was light and evenly distributed; second pressure at the base of the thumb was lighter" (F). (3-5—) "First pressure greater on the forefinger; second pressure lighter on the thumb" (F). (4-3—) "Pressure with the first was greater; no other difference" (F). (5-3) "With the up whip the pressure was more intense than in the second, but when the rods came down the intensity of the pressures was equal" (H). (2-3) "The immediate impression was one of slightly greater intensity on the forefinger with the second. When whipped the intensity became the same as the first" (H). (3-2) "First impression was 'shorter' but with the whip they became 'equal'. The pressure at the base of the thumb was, at first, weaker with the second but increased with whipping" (H). (3-1—) "The second experience seemed a little more diffuse but a little less extended. I did not notice any difference in intensity. It was more a judgment of inference than one of direct experience" (H).

*Conclusions.*—We conclude that the perception of the length of vertically whipped rods depends primarily upon the relative intensity of two opposed pressure experiences in the hand.

In addition, the most important items of experience for the perception and those which contribute most to its refinement are the differences in the frequency and rate of intensive changes with the whip.

The perception of difference in length correlates highly with difference in center of mass, and somewhat with difference in length of the stimuli.

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## LVII. ON THE NON-VISUAL PERCEPTION OF THE LENGTH OF HORIZONTALLY WHIPPED RODS

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By A. S. BAKER

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In every-day life the tools and instruments which we use move or act for the most part in the vertical plane; moreover, if one gives a rod to a blind-folded subject and asks him to judge its length, he will almost invariably whip it up and down. If, then, the perception is one in which the integration of the processes depends upon past experience, we should expect the perception of the length of a horizontally whipped rod to be less refined, less accurate in terms of stimulus, than that of the vertically whipped rod. On the other hand, since the psychophysical processes have a common origin and no new or lacking moment in the stimulus can be assumed *a priori*, we might expect the perception to be as accurately determined in the one case as in the other; the usual vertical whip being a muscular rather than a perceptual habit.

We did the experimental work for this study during the Summer term of 1921. The general procedure and apparatus were the same as in the preceding study by Shults.<sup>1</sup>

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<sup>1</sup>Erna Shults, On the non-visual perception of the length of vertically whipped rods, *Amer. J. Psych.*, xxxiii, 1921, 135 ff.